DRRC Demand Response Research Center

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DRRC Technical Advisory Committee Webcast

A Framework for Demand Response Valuation

Initial Findings + Research Agenda

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Grayson Heffner

GLOBAL ENERGY ASSOCIATES, INC.

When you measure what you are speaking about and express it in numbers, you know something about it, but when you cannot (or do not) measure it, when you cannot (or do not) express it in numbers, then your knowledge is of a meager and unsatisfactory kind.

- Sir William Thompson, Lord Kelvin (1824-1907)

DR Valuation Frameworks Study – Project Scope

1. **Review the DR valuation literature**
2. **Prepare a framework for identifying DR benefits & matching them to beneficiaries**
3. **Develop Research Agenda for future DRRC work**
4. **Explore applications to DR policy & regulation**

Definition of Value Varies by Discipline

- The Accountant looks for Asset Value, either:
  - Absolute, based on performance, net present value or book value
  - Relative to other assets in risk or financial benefits
- The Trader looks for Fair Market Value: The price at which an asset changes hands
- The Engineer looks for a Value Function that can relate the Cost of Reliability to its Value to Customers
- The Economist looks for Consumer or Producer Surplus - Willingness-to-pay less market price

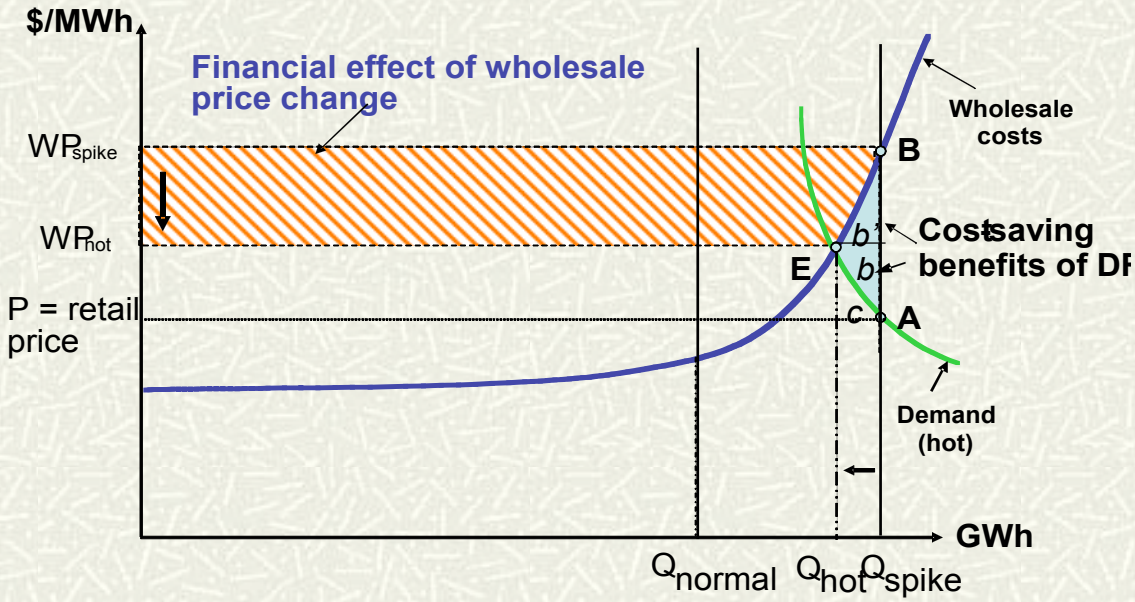
Range of Valuation Methods in Use

- Avoided Cost Methods
  - Approach: PV of avoided capacity, energy costs and T&D costs
  - Utility Straw Proposal in R.07-01-041
- Resource Planning Methods
  - Approach: NPV of ΔSystem Costs with & w/o DR
  - Example: NPCC 5th Power Plan
- Welfare Analysis Methods
  - Approach: Impact of DR on wholesale prices and customer costs
  - Example: Brattle Study of DR Benefits for PJM
- Value of System Reliability
  - Approach: Δ Expected Unserved Energy * Δ LOLP
  - Example: NYISO
- Transmission Planning Approaches
  - Approach: Δ Congestion Costs in Load Pockets w/ & w/o DR
  - Examples: ISO-NE 2002 & 2003 Regional Transmission Plans
- Capacity Markets
  - PJM's Forward Capacity Auction

Range of DR Benefits

- Direct Financial Benefits
- Collateral or Indirect Financial Benefits
  - All consumers
  - Constitute scarcity rent transfers from producers
- Reliability Benefits
  - Resource Adequacy Planning Value
  - Value of Lost Load
- System and Network Benefits
- Societal Benefits

Direct vs. Collateral Financial Benefits of Demand Response[1]



[1]taken from: *Quantifying Demand Response Benefits in PJM, The Brattle Group*, January 2007

No Single Valuation Method Captures all DR's Benefits

	Avoided Cost Methods	Resource Planning Methods	Welfare Analysis Methods	Value of System Reliability	Transmission Planning Approaches	Forward Capacity Auctions
Direct Financial Benefits	√		√			
Collateral or Indirect Financial Benefits		√	√		√	
Reliability Benefits		√		√	√	√
System and Network Benefits				√	√	√
Societal Benefits	√		√			

Some Methods May be Better Suited to Valuing Certain Types of DR

	Avoided Cost Methods	Resource Planning Methods	Welfare Analysis Methods	Value of System Reliability	Transmission Planning Approaches
Demand Curtailment/ Bidding	√	√	√		√
Dynamic Pricing			√		√
Emergency Demand Response	√	√		√	
Load Following Auto-DR			√		

Value, like Beauty, is in the Eye of the Beholder

Test Perspectives in SPM

- Participant
- Ratepayer
- Administrator
- Society
- TRC

Emerging Test Perspectives

- CAISO
- Generators
- LSEs
- 3rd Party Providers
- Direct Access Customers

First Cut at a Valuation Framework

		BENEFICIARIES			
		Participating Consumers	All Consumers	Load Serving Entities	Society (including Generators)
DIRECT	Bill Savings	√			
BENEFITS	Incentive Payments	√			
	Avoided risk hedge premium	√			
RELIABILITY	Improved Reliability	√	√	√	√
BENEFITS	Alleviating Network Overloads	√	√	√	√
NETWORK	Reducing Nodal Prices	√	√	√	√
BENEFITS	Deferring Network Additions	√	√		
	Reducing Transmission Congestion	√	√	√	√
COLLATERAL	Short-term Market Benefits [1]	√	√	√	
BENEFITS	Long-term Market Benefits [2]	√	√	√	
	Retail Consumer Choice	√	√	√	
	Market Power Mitigation	√	√	√	
SOCIETAL	Improved Resource Allocation	√	√	√	√
BENEFITS	Local & Global Emissions Reduction	√	√	√	√

[1] Includes event-driven energy price reductions & lower power procurement contract costs

[2] Includes lower capacity procurement costs & lower RA requirements

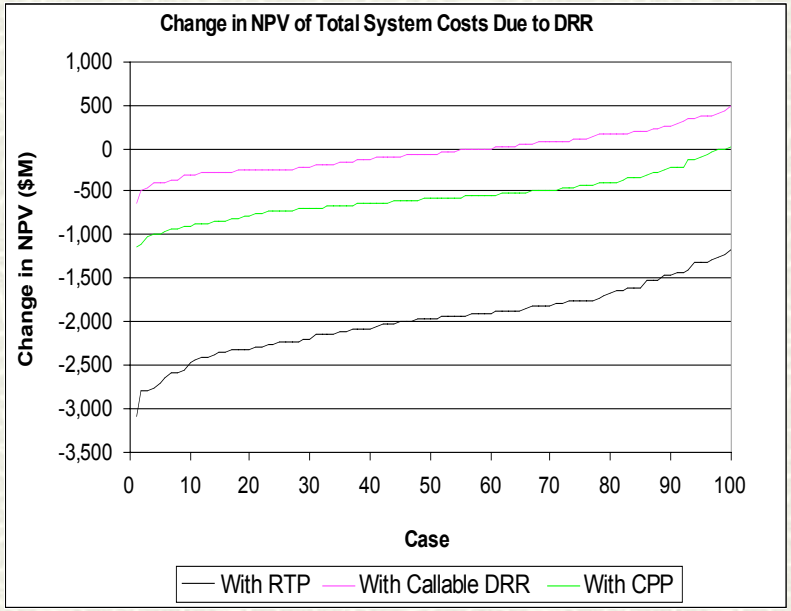
1 Review the DR valuation literature

DR Valuation Approaches & Results

- Integrated Resource Planning approaches
  - Long term
  - Focused on minimizing system costs & maintaining reliability levels
- Market Performance Evaluations
  - *ex post*
  - short term
- Market simulation studies
- Capacity Market Results

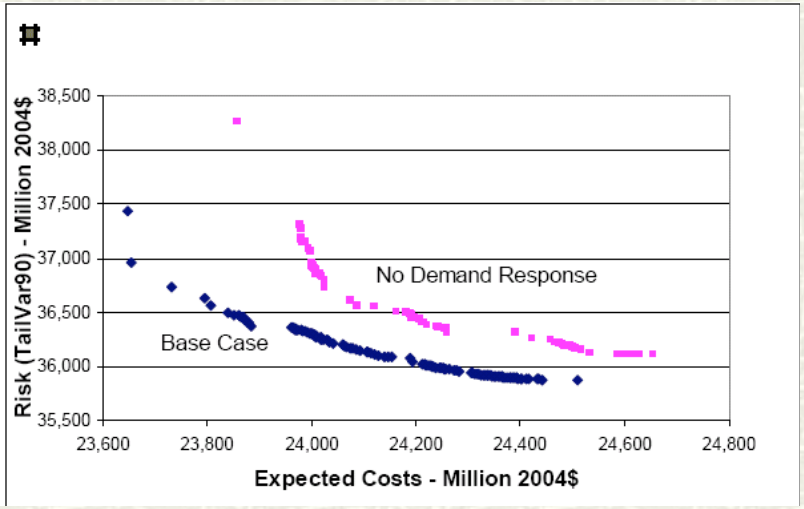
Resource Planning Studies	Program Evaluations	Market Benefits Studies	Capacity Auctions
IEA DR Case Study, Summit Blue 2006	NYISO 2002 DR, Neenan 2003	ISO-NE Retail RTP Study, Neenan 2005	Forward Capacity Auction, PJM 2007
Fifth NW Resource Plan, NW Power Council 2005)	ISO-NE 2004 DR, RLW & Neenan 2004	Quantifying DR Benefits in PJM, Brattle Group 2007	

*Demand Response Resource Valuation and Market Analysis (*Summit Blue Consulting, January 2006)



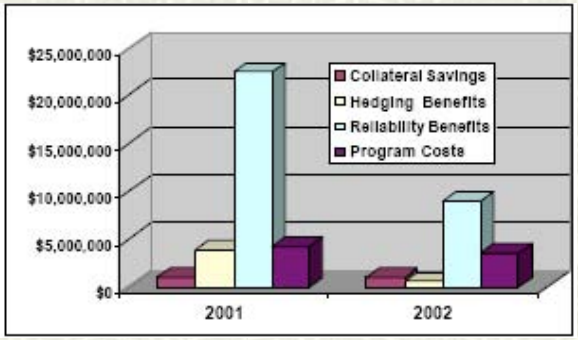
- Value of DRR depends on:
  - Dimensioning uncertainty
  - A long view, to capture hedging value of DR
  - Portfolio approach to DR
- RTP for large customers is most cost effective DR, as program costs are minimal and price-responsive load always reduces system costs
- Benefits of active DR, especially in "stress" cases, offset by the program cost, even when not used.

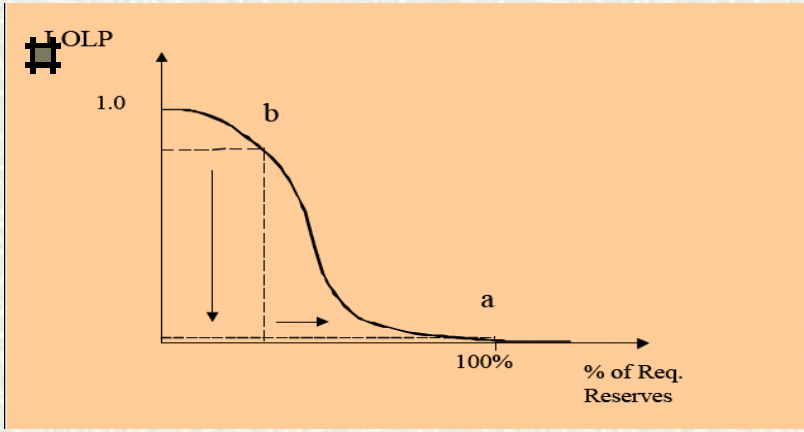
The Fifth Northwest Electric Power and Conservation Plan (Northwest Power and Conservation Council, January 2005)



- 2,000 megawatts of DR was considered
- Withholding DR from the portfolio analysis increased expected cost by $300 - $500 million
- Demand response found extensive use (up to 870 hours per year) in about 5 percent of all simulated years.
- Based on this analysis the Fifth Power Plan calls for 500 MW of DR

A Study of NYISO and NYSERDA 2002 PRL Program Performance, Neenan Associates, Jan. 2003)





Market Benefits:

- EDRP load curtailments reduced real-time LMPs from 5 % to over 25%
- Reliability and hedging benefits were much higher in 2001, when the program was operated more frequently and price levels were generally higher

Reliability Benefits:

- A VOLL of $5,000/MWh and assuming 5 percent of NYISO load was at risk during the reserve shortfall, reliability benefit estimates ranged from $2 to $17 million
- Variability due to the assumed level of reduction in LOLP due to assumptions regarding the slope of the LOLP curve

An Evaluation of the Performance of the Demand Response Programs Implemented by ISO-NE in 2004, RLW Analytics and Neenan Associates, December 2004)

ISO-NE Price Response Program Impacts					
Season	Bill Savings	Hedge Savings	Total Savings	Program Payments	Market Impact Ratio
Fall/Spring	$7,313	$900,375	$907,687	$196,336	462%
Winter	$212,674	$3,405,415	$3,618,089	$801,269	452%
Summer	$2,759	$347,814	$350,573	$42,601	823%
Total	$222,745	$4,653,603	$4,876,349	$1,040,206	469%

- Price-responsive curtailments took place all year; however, lower price flexibility in summer resulted in small LMP changes:
  - $0.12 - $0.06/MWh (Summer and Fall)
- Most of the bill and hedge savings occurred during the wintertime when natural gas shortages created price volatility during cold snaps
  - $1.00/MWh (about 1 percent) during winter curtailments
- Overall market impacts were almost five times program payments

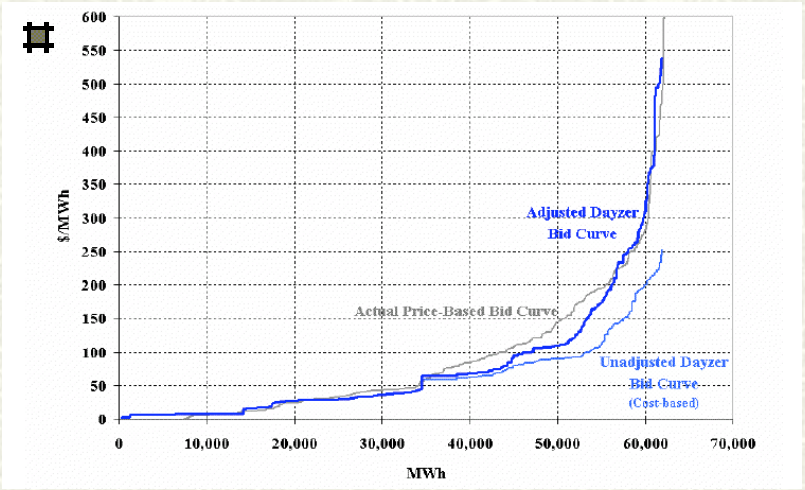
Improving Linkages Between Wholesale and Retail Markets Through Dynamic Retail Pricing, Neenan Associates, December 2005)

	Status Quo Year		Normal Year		Extreme Year	
	All	Responsive Only	All	Responsive Only	All	Responsive Only
Aggregate DR	353 MW	307 MW	378 MW	328 MW	410 MW	357 MW
Customer Bill Savings	$73.1M	$24.4M	$106.2M	$37.0M	$134.2M	$48.0M
Electricity Market Transfer Savings	$1.3M	$1.1M	$15.6M	$13.5M	$38.2M	$33.1M
Social Welfare Improvements*	$0.1M	$0.1M	$0.9M	$0.7M	$2.1M	$1.6M
ICAP Market LSE Savings	$0M	$0M	$15.4M	$13.4M	$75.8M	$65.9M
ICAP Market Transfer Savings	$0M	$0M	$0.9M	$0.8M	$6.1M	$5.3M

* Represents gross social welfare improvements, not net improvements that have the cost to achieve them imbedded

- Only about 1/3 of the largest customers (over 1 MW) had sufficiently high price elasticities to benefit from DADS
- Total market benefits over 5 years estimated at $340 million, about half of which accrued to all consumers via lower market prices
- Market benefits almost doubled in “extreme years”
- Hypothetical costs to implement DADS for the 5200 customer greater than 1 MW was $5 million per year – yielding a B/C ratio of 14:1

Quantifying Demand Response Benefits in PJM (The Brattle Group, January 2007)



- Study of how demand curtailment would impact PJM wholesale prices
- Dayzer market model simulated a 3% load curtailment on LMPs on the 20 highest-priced days
- Scenarios captured 1-in-20-year demand conditions
- Reduced zonal prices of $85 to $234 per megawatt-hour for the highest-cost hours, yielding $57-182 million in bill savings
- Reduced capacity due to a modified load shape that excludes the zonal "super-peaks", estimated at $73 million per year

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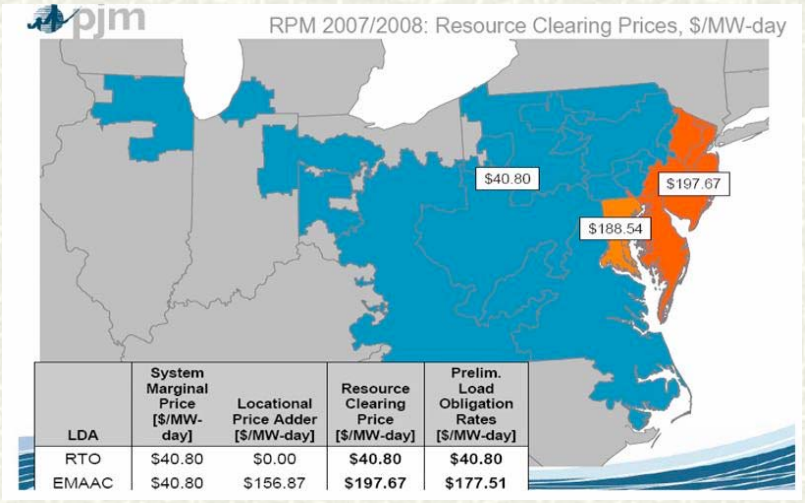
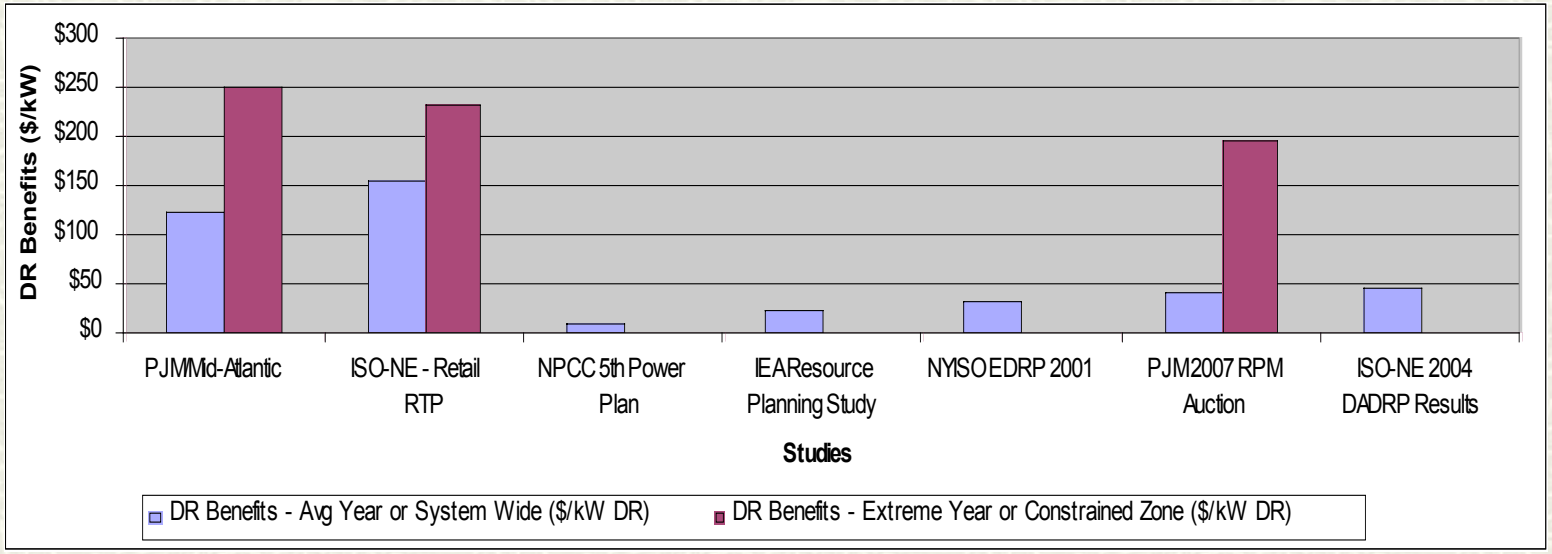
PJM Forward Capacity Auction, 2007



LDA	System Marginal Price [$/MW-day]	Locational Price Adder [$/MW-day]	Resource Clearing Price [$/MW-day]	Prelim. Load Obligation Rates [$/MW-day]
RTO	$40.80	$0.00	**$40.80**	**$40.80**
EMAAC	$40.80	$156.87	**$197.67**	**$177.51**

- Phase-in of PJM's new capacity market includes quarterly auctions for capacity deliveries in 2008-2011
- First-ever forward capacity auction (April 2007) revealed large zonal differences in the value of capacity
- Second auction for 2009 capacity attracted 1,300 MW of new resources, half of which were DR
- The California Forward Capacity Market Advocates (CFCMA) advocate a similar capacity auction to create transparent capacity markets in California

Comparison of DR Benefit Estimates



- DR benefit estimates vary widely according to analysis method and scope of benefits included
- "Stress cases" and zonal constraints can skyrocket the value of DR
- Need to take considerable care to consider what constitutes a distinct benefit and what may constitute double-counting

2 **Prepare a framework for identifying DR benefits & matching them to beneficiaries**

Elements of a Valuation Framework

- Should accommodate all potential benefit streams
  - Reliability benefits
  - Direct financial benefits
  - Collateral/market benefits
  - System and network benefits
  - Societal benefits
- Should resolve any wholesale-retail seams issues
- Should accommodate emerging stakeholder perspectives
- Should allocate value according to DR attributes
- Should accommodate improvements in estimation methods
- Should be practical and transparent

Valuation Framework should mend the Wholesale-Retail Seams Issue

	Retail	Wholesale
System-Wide	RA benefits Global environmental benefits EE and DR Complementarity Consumer Choice	Collateral/market benefits Reliablity services provision Emergency operating flexibility Mitigating generator market power
Location-Specific	Alleviating network overloads Deferring network investment Local environmental benefits	Alleviating transmission congestion Reducing line losses Reducing nodal prices
Participant-Specific	Bill Savings Incentive Payments Avoided hedge premiums	

CAISO View of DR Value

1

DR has value if it reduces the load forecast

- In the day-ahead market
- In the resource plan

2

DR has value if it provides reliability services

- Spinning and non-spinning reserves
- Balancing Services

3

DR has value if it provides operational flexibility during emergencies

Valuation Framework should be able to Calculate the Comparable Worth of non-equivalent Resources

	Resource Attribute	Direct Control	Price Response
1	Advance Notice	●	●
2	Availability	●	●
3	Ramp Rate	●	●
4	Load Factor	●	●
5	Persistence	●	●

● Full Source Equivalency

● Variable but predictable & measurable

● Variable and unpredictable

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3 Develop a Research Agenda for future DRRC work

How do we get there with a DR Research Program?

Research Priorities

1. Market Benefits of DR
2. Capacity Procurement Benefits of DR
3. Reliability Services Benefits of DR
4. Allocating Value according to Resource Attributes
5. Quantifying System and Network Benefits
6. Customer cost to participate & value of service
7. Improving the SPM
8. Alternative Methods of Capacity Valuation

Market Benefits of DR

Description

- Price responsive loads bid into forward and real-time markets lower the clearing price, providing short and long-term market benefits to all consumers

Research Needs

- No estimate of market benefits has been made since the E3 estimate using old PX data
- Estimating market benefits requires an economic supply model of the wholesale power market
- Develop a model to simulate the impacts of price-responsive and other DR in the MRTU

Capacity Procurement Benefits of DR

Description

Sustained DR reduces capacity costs in 3 ways:

- Reserve margins can be set lower due to price-responsive demand;
- Long-term contracts should be priced lower due to competition from loads
- Operating reserves can be lowered w/ load response

Research Agenda

- Evaluate the relationship between DR bid into the DAM and RUC requirements
- Examine potential of retail dynamic pricing to reduce reserve margin and operating reserve requirements
- Evaluate the capability of MRTU Release 1 to accommodate DR in the DAM

Reliability Services Benefits of DR

Description

- Spinning & Non-Spinning Reserves, Upward and Downward Regulation
- CAISO operates day-ahead and hour-ahead RS markets
- LSEs must procure Reliability Services on a zonal basis, with CAISO procuring any imbalance
- Most parties benefit from reducing reliability service costs

Research Agenda

- Identify benefits of load participation, drawing from experience elsewhere
- Scale-up pilots of DR providing reliability services
- Determine any barriers to load participation, such as reliability rues
- Potential for DR to reduce:
  - Over & under-scheduling
  - Energy imbalance volumes
  - RS bid-insufficient hours

Allocating Value according to Resource Attributes

Description

- **Attributes include:**
  - Advance Notice
  - Availability (Frequency & Duration)
  - Ramp Rate (Load Following)
  - Load Factor
  - Persistence
  - Spatial Granularity

Research Agenda

- Review capacity value allocation methods in use in other markets, notably the NEM and Nordic Power Market,
- Further develop option valuation and Monte Carlo methods for allocating value, per the utility straw proposal
- Develop new methods to allocate value of reducing congestion

Quantifying System & Network Benefits

Description

- Operating Flexibility
- Environmental Benefits
- Alleviating transmission congestion
- Reducing nodal prices
- Network asset protection
- Network investment deferral
- Reducing line losses

Research Agenda

System Benefits:

- Operating reserves as a public good
- Review Reliability benefits calculation approaches
- Insurance value of DR

Network Benefits:

- Utilizing ACLM to reduce overloads
- Utilizing DR to prevent FLT failure
- Utilizing DR to relieve transmission congestion

Customer Cost to Participate & Value of Service

Description

- Filings in R.07-01-041 underscore a general lack of understanding of customer costs to participate
- Customer costs include two aspects – compliance/shutdown costs, and foregone value of service
- Earlier studies done on a class level were unable to discern value of service to the end use level

Research Agenda

- Update work on VOS and outage costs to better quantify the "strike price" for customers to forego consumption under given conditions
- Develop better research on coping strategies including enabling technologies that allow customers to accommodate foregone or reduced levels of service
- Differentiate between DR program types in terms of compliance costs and reduced levels of service

Improving the SPM

Description

- Current SPM is dated
- Does not reflect new market structures or participants.
- Calculation procedures cannot accommodate economic surplus not reflected in utility costs or bill reductions

Research Agenda

- Explore other economic evaluation methods that can explicitly incorporate consumer surplus, value of reliability, market impacts and distributional effects, and customer costs into the evaluation

Alternative Methods of Capacity Valuation

Description

Lack of transparent capacity markets in California makes it difficult to determine the fair market value of capacity. Proxy methods such as the adjusted cost of a new CT are an imperfect and always controversial substitute for a market price.

Research Agenda

- Consider whether a forward capacity auction would accelerate market-based DR for California
- Consider IRP approaches (NPV of system costs or levelized RR of a least-cost plan) as an alternative to proxy methods

Some Preliminary Conclusions

- Valuation based only on capacity benefits will undercount the market and system/network benefits of DR
- A market simulation of the effects of dynamic pricing for price-responsive customers in California would help understand the potential market benefits of DR
- A collaborative effort with CAISO would help identify the potential magnitude of DR's system and network benefits
- The SPM need to be rethought in order to reflect new market participants and enhance the capability of evaluating changes in economic surplus due to DR
- California should seriously consider ways to introduce more transparency into capacity procurement

Contact Information

Demand Response Research Center (DRRC)

Grayson Heffner
DR Valuation Frameworks Project
Phone: 301-330-0947
email: gcheffner@lbl.gov

Global Energy Associates, Inc.
15525 Ambiance Drive
N. Potomac, MD 20878

Annex – Supplemental Slides

Summary of DR Benefits Studies

	Resource Planning Studies		Program Performance Studies		DR Comprehensive Benefits Studies	
Study Title	IEA DR	Fifth NW	NYISO 2002	ISO-NE 2004	Default Retail RTP	DR Benefits for
	Case Study	Resource Plan	DR Evaluation	Evaluation	in ISO-NE	MADRI
Market Structure	Integrated	Integrated	Organized	Organized	Organized	Organized
DR Mechanism	Interruptible, DLC, RTP	Demand Curtailment	Day-of demand curtailment	Day-ahead demand bidding	Retail day-ahead RTP for large customers	Day-ahead demand curtailment
Delivered DR as percentage of Peak	15 percent	8 percent	2.5 percent	0.5 percent	1.3 percent	3 percent
Time Horizon	20 years	20 years	Actual year	Actual year	Reference Year + Extreme Scenarios	Reference Year + High/Low Demand Scenarios
DR Benefits Considered	System Cost Savings	System Cost Savings	Direct & collateral benefits + reliability	Direct & collateral benefits	Direct & collateral benefits + RA benefits + improved social welfare	Direct & collateral benefits + RA benefits + improved social welfare

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